Slovak Journal of Food Sciences

OPEN ACCESS

Received: 29.10.2023
Revised: 14.1.2024
Accepted: 9.2.2024
Published: 19.2.2024

Potravinarstvo Slovak Journal of Food Sciences
vol. 18, 2024, p. 122-138
https://doi.org/10.5219/1933
ISSN: 1337-0960 online
www.potravinarstvo.com

Quality characteristics of the shape preservation of cooked pasta with millet addition at different time intervals

Gulmaida Karimova, Rimma Niyazbekova, Khaldun Al Azzam, El-Sayed Negim

ABSTRACT

The current study presents the indicators of shape preservation of cooked pasta by adding 7.7% millet in various time intervals. The experiments were conducted immediately after the pasta cooking process and after two hours. In the Eurasian Economic Union and the Republic of Kazakhstan, the quality indicators were produced by considering the established methodologies stated in the standardized papers. The interstate standard GOST 31964-2012, "Pasta products. Acceptance rules and methods of quality determination," was used to determine the shape preservation of cooked pasta. The study aimed to determine and compare cooked pasta's shape preservation indicators (consumer properties), considering a certain time interval. Pasta needs five minutes to cook. These days, though, pasta manufacturers specify the required cooking time – eight, nine, ten, or eleven minutes – on their packages. The study's findings indicate that the safety of pasta containing "7.7% millet after 2 (hours) from the moment of cooking" and "with the addition of 7.7% millet after cooking" is negligible by 1-2 N; however, data from 4-24 N show a more notable difference in a comparable scenario. The experiments were conducted at the Federal State Autonomous Scientific Institution "Scientific Research Institute of the Bakery Industry", Moscow, Russian Federation. The corresponding data was obtained according to the results of the conducted studies.

Keywords: pasta, cooking, time, quality indicators, shape, safety, standardization documents

INTRODUCTION

Globally, health authorities advise reducing animal protein and fat consumption while increasing cereal consumption, which is an important source of dietary fiber. In addition, the World Health Organization (WHO) considers pasta, a cereal product, to be a good way to supplement nutrients **[1]**. Made from durum wheat flour, pasta is a classic dish staple in many nations. Customers choose it because of its inexpensive cost and low glycemic index, as well as its ease of handling, cooking, storing, and transportation (2-4) **[1]**, **[2]**.

Pasta is a widely used cereal cuisine that may be found in many different forms and sizes, including noodles, spaghetti, and vermicelli **[3]**, **[4]**. It is mainly produced from durum wheat because of its favorable viscoelastic behavior, which is in charge of good matrix networking and ideal dough formation during the mixing and extrusion phases. Pasta quality attributes that are cooked result from a well-designed matrix network **[3]**.

Several studies on the value addition of various millets have been reported **[5]**, **[6]**, **[7]**, **[8]**, but little effort has been made to prepare small millets-based pasta products, possibly due to a variety of factors, including a lack of technology.

After three months of storage, there were no discernible differences in the sensory qualities of cooked pasta produced using hot water extrusion, and cooking loss was minimal (12%). Since there hasn't been much research on the creation of snack products made from Kodo millets, there haven't been any studies on the packaging and storage of products that resemble pasta that is ready to cook but contain Kodo millet. As a result, a study was carried out developing Kodo millet-based extruded ready-to-cook pasta products under various formulations packed in different packaging materials for three months of storage studies with biochemical (fat, protein, carbohydrate, crude fiber, ash, and moisture content) and quality analysis at monthly intervals, to provide a good processing, packaging, and storage technique for pasta-like ready-to-cook products **[9]**.

Promoting nutrition reform has increased millet (*Panicum miliaceum* L.), receiving a place in food processing today. The short growing season of millet and its variety of uses increase its value. The outcomes of numerous animal experiments demonstrate that millet has a cholesterol-lowering effect. Millet has several advantages for treating diabetes and is crucial for maintaining good health. Fluorine, iron, magnesium, calcium, zinc, potassium, and manganese are also significant in millet. The excellent yellow color of pasta results from its high carotenoid content, provided by millet use. Additionally, it lowers the finished products' GI (glycemic index) and contains a significant amount of vitamins, particularly β-group vitamins. People with coeliac disease can eat millet because it is gluten-free. Still, clean millet that any other cereals haven't contaminated can be difficult to produce in our country **[10]**.

Pasta is one of the favorite dishes in the world. They are traditionally made from wheat, but nowadays, there are many more types of pasta, for example, pasta made from peas, lentils, beans, and other gluten-free varieties **[11]**. Today, one of the priority quality indicators in pasta is preserving the shape after cooking. The consumer focuses his attention on this indicator. The method for determining the quality indicator is established in GOST 31964-2012 "Pasta products". Acceptance rules and methods of quality determination" **[12]**. Given this, experiments were conducted regarding the influence of the time factor on the indicators of the preservation of the shape of pasta. The study aimed to assess and compare cooked pasta's shape preservation indicators (consumer characteristics) over a specific time frame. The trials were conducted at the Federal State Autonomous Scientific Institution "Scientific Research Institute of the Bakery Industry" in Moscow, Russia. The related data was gathered based on the findings of the investigations.

Scientific Hypothesis

The major scientific hypothesis of the study is to determine and compare the shape preservation indicators (consumer properties) of cooked pasta, considering a certain time interval. We expect that the cooked pasta's consumer qualities (shape preservation indicators) over a given cooking period will affect its quality and thus affect the consumer's needs.

MATERIAL AND METHODOLOGY

Samples

The following items were bought from Almaty, Kazakhstan local markets: millets, wheat flour, starch, pea, soy, amaranth flour, gluten-free flour, durum wheat (genotype), and flax seeds. Pasta usually consists of two ingredients: water and wheat flour. Sampling pasta with millet 7.7% was conducted according to GOST 31964-2012. The process of cooking pasta with the addition of 7.7% millet, according to GOST 31964-2012. The samples (pasta) temperature was conducted at a range of 24-25 °C.

Chemicals

The chemical composition (starch and amaranth flour, gluten-free flour, soy, pea) was determined.

Animals, Plants and Biological Materials

This study did not use any biological or animal components.

Instruments

Russian Federation, Moscow, Eleks -7M (Manufacturer Limited Liability Company "Tagler"). Ukraine, Vinnytsia area, Mogilev-Podilskyi, instrument manufacturing facility, drying cabinet SESH-3M. Furthermore, during product input/output control and scientific research, the MA-150 "SARTORIUS" infrared humidity analyzer is designed to track the humidity level in liquid, bulk, solid, and emulsion substances. Göttingen, Germany, "Sartorius Weighing Technologies GmbH," manufacturer. 94-108 Weender Landstrasse. The Structurometer ST-1M may determine the rheological characteristics of raw materials, semi-finished items, and final goods – producer "Ochakov Combination of Food Ingredients," Moscow, Russian Federation.

To accommodate gluten-intolerant patrons, pasta was enhanced with gluten-free flour, such as rice, buckwheat, and maize. Other components such as amaranth flour, peas, starch, and soy were added to gluten-free flour. Pasta products gained biological value and acquired therapeutic and preventative qualities when flaxseed flour was partially substituted for the best wheat flour grade. Regarding amino acid composition, the proteins in flaxseed flour are far superior to those in wheat. The fiber in flaxseed flour can reach 30% of its weight. Additionally, incorporated in flaxseed flour are readily absorbed minerals and vitamins.

Many domestic and foreign researchers have discussed the need for this direction in their search for novel raw materials and functional additives for pasta production. Their goal is to produce pasta that is higher in nutritional value, lower in calories, and enhanced with active ingredients **[13]**, **[14]**. We use millet in our research as a dietary supplement.

About 12-15% of the protein, 70% of the starch, and essential amino acids are found in millet. Cereals contain between 0.5 and 8% fiber, 2.6-3.7% fat, up to 2% sugar, vitamins PP, B1, and B2, and significant amounts of potassium, magnesium, and phosphorus. Magnesium and molybdenum concentrations are highest in millet. The grain crop that is thought to be the least allergic is millet. Even people with sensitive digestion can consume this cereal because the body easily absorbs it.

Laboratory Methods

According to the specifications of GOST 31743-2017 "Pasta products, General Technical Conditions" and GOST 31964-2012 "Pasta products, Acceptance Rules and Methods of Quality Determination," studies were conducted on organoleptic parameters (color, shape, taste, and smell), as well as physicochemical parameters, such as humidity. The temperature used was in the range of 24-25 °C.

There are the following methods for determining humidity according to GOST 31964-2012:

- by drying to a constant mass.
- accelerated drying method.
- by the express method.
- on the MA-30 "SARTORIUS".

The organoleptic indicators of millet, including indications such as color, smell, and taste, are considered by GOST 572-2016 "Millet grain ground. Technical conditions."

The millet groats should have a color that is "yellow of various hues," a fragrance that is "typical of millet groats, without foreign odors, not musty, not moldy," and a taste that is "typical of millet groats, without foreign tastes, not sour, not bitter."

In preparing pasta, high-grade grits, ground millet, and water were used. The water intended for kneading the dough is heated in heat exchangers and mixed with cold tap water to the temperature specified in the recipe. The longitudinal section of the wheat grain shown in Figure 1 consists of shells 1, aleurone layer 2, endosperm 3, and embryo 4. When moistened with cold water, starch grains partially swell, retaining their shape and not dissolving. When an aqueous suspension of wheat starch is heated, the volume of starch grains increases, swelling due to the absorption of a large amount of water. At 20-300 °C there is an increase in the volume of grains with the preservation of their individuality, but with the loss of the crystallinity of the structure; at a temperature of 62.5 °C, the process of gelatinization of wheat starch begins, accompanied by the absorption of a significant amount of water, the rupture of polysaccharide chains, and the transformation of starch grains into a single body-like, jelly-like mass – paste; with further heating of the paste, starch absorbs five times the amount of water or more **[15]**. By the requirements of GOST 31743-2017 "Pasta products. General technical conditions", GOST 31964-2012 "Pasta products. Acceptance rules and methods of quality determination"**[16]**. By GOST 572-2016 "Millet grain ground. Technical conditions"**[17]**. Equipment used during experiments according to GOST 31964-2012. Laboratory scales according to GOST 24104. Electric stove, according to GOST 14919. They are cooking vessels with a thick bottom with a diameter of 170 mm and a capacity of 2.0-2.5 mL. Pressure plate made of transparent plastic with a thickness of 3 mm. A sieve with a diameter of 200 and a hole size of 1-2 mm. A stopwatch with a permissible error when measuring the interval up to 30 min ± 3 s. Distilled water according to GOST 6709. The plates are white. "Structurometer ST-1M" is designed to determine the rheological characteristics of food media (Figure 2). The device's operation principle measures the mechanical load on the indenter nozzle when inserted at a given speed into the prepared product sample. The microprocessor system of the device provides a certain measurement algorithm and the output of measurement results in an alphanumeric indicator and a personal computer. The device Structrometer ST-1M determines one of the quality indicators of «shape preservation» of pasta. The structure meter is designed to determine the quality indicators of prescription ingredients, semi-finished products, and finished products in various branches of the food industry according to their classical and conditional rheological characteristics:

- elastic and plastic deformations;
- the work of elastic deformation;
- rigidity;
- ultimate strength;
- modulus of elasticity;
- the maximum loading force;
- adhesive stress;
- the maximum shear stress;
- viscosity;
- stress relaxation time;

- elastic after effect;
- strength of jelly (gelling ability of agaroids and pectin-containing raw materials);
- hardness of fatty foods;
- general deformation of gluten;
- strength of pasta, pastry, and chocolate products;
- the depth of implementation;
- swelling of bread and flour confectionery products.

Thus, the structure meter is an information and measurement system for complex measurement of the rheological properties of food products. With a high degree of automation of the measurement process, it provides control of a wide range of rheological parameters. Given the versatility of the device, and its ability to determine the rheological characteristics of food products quickly and accurately, it is possible to use it both during scientific research and during input control of raw materials entering enterprises and operational control of the flow of technological operations of food production.

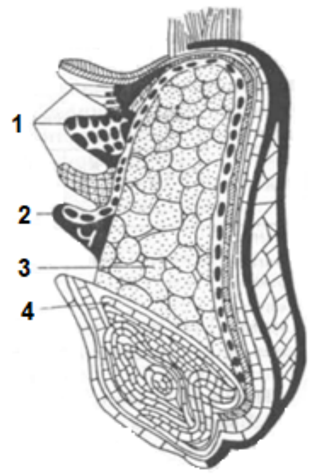


Figure 1 Longitudinal section of the wheat grain.

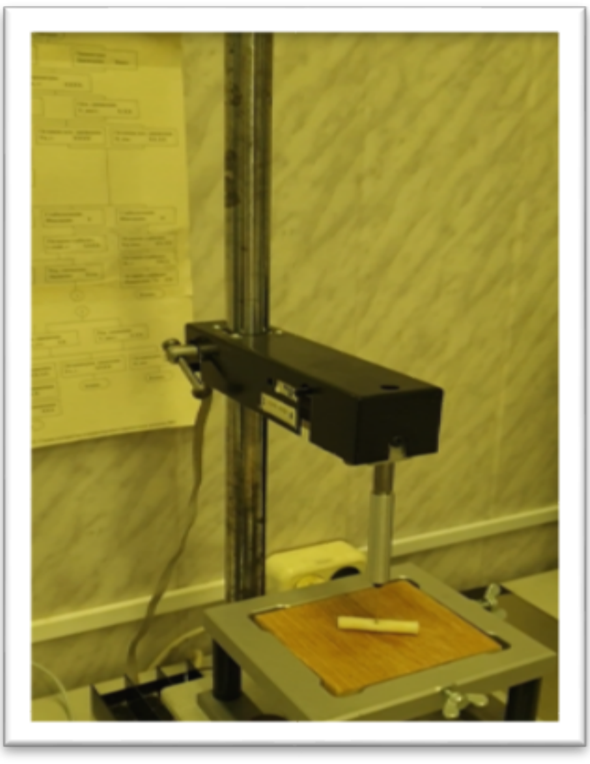


Figure 2 The device for determining the preservation of the form "Structrometer ST-1M", aimed at identifying the rheological properties of semi-finished, final, and raw materials; Moscow, Russian Federation; manufacturer: "Ochakov Combine of Food Ingredients."

Description of the Experiment

Sample preparation: The study was conducted at the Federal State Autonomous Scientific Institution "Research Institute of the Baking Industry," one of the top research facilities in Moscow, Russian Federation.

In a cooking vessel, 1000 mL of distilled water was added and then boiled. A sample for analysis weighing 50 g (based on the entire product) was cooked while being stirred in boiling water until the water reached boiling once again.

The product obtained was cooked in an open vessel at moderate heat, and their readiness was monitored with a pressure plate every minute after secondary boiling until the continuous white line visible in the centre of the plate disappeared. The time it takes for the product to be ready was set - from when the pasta is placed in boiling water until the continuous white line disappears. The cooked pasta was poured onto a sieve, allowing the cooking water to drain, and then put on a platter.

An apparatus made by "KERN & Sohn GmbH" in Balingen, Germany, model number KERN 440-45N, was used to weigh the grits. Using the Sandorina model, number 1861 equipment (made in Italy, 2002; Watt 400, Volts 220, Hz 50, Ph 1), the dough was kneaded with millet for around thirty minutes. The millet component's volume was determined to be 670 microns. As a control copy, water and premium grits were used.

Number of samples analyzed: 36.

Number of repeated analyses: 9.

Number of experiment replication: 3.

Statistical Analysis

The data are provided as the mean standard deviation (SD) of three experiments, with p <0.05 denoting significance. The study's data were statistically analyzed using Excel and STATISTICA 13 software (Dell, StatSoft). The difference between the values was considered probable p <0.05; 0.01 and 0.001.

RESULTS AND DISCUSSION

The shape preservation of pasta made of premium grade grits and adding 7.7% millet was determined on a texture analyzer device (structurometer ST-1M) (Figure 3). The moisture content of pasta was 28% at the pressing stage.

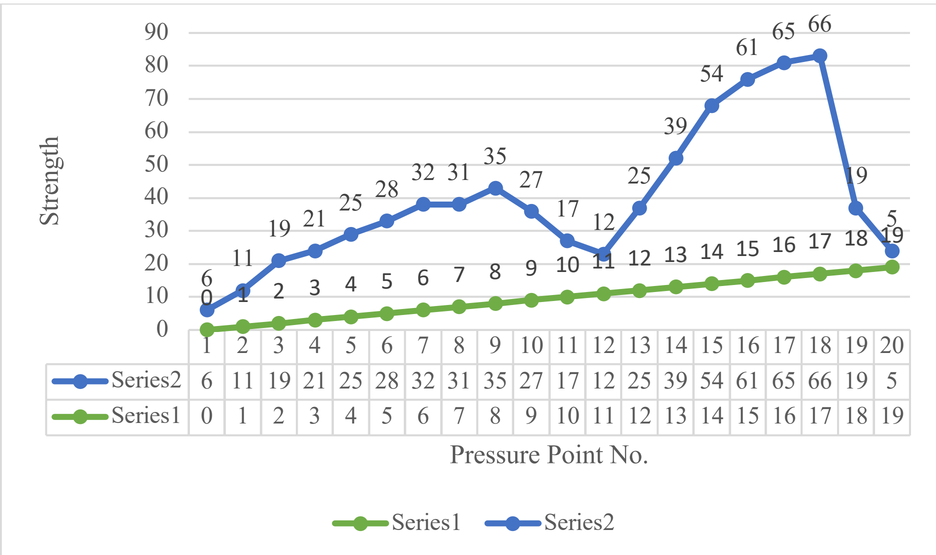


Figure 3 Strength indicators of pasta made from high-grade grits control (sample No. 1).

An essential component of assessing the product's overall quality and consumer acceptance is the evaluation of form preservation in pasta. The structure meter ST-1M, a texture analyzer equipment, was used in this investigation to examine the form preservation of pasta prepared from premium-grade grits and pasta with an addition of 7.7% millet (Figure 3). The selection of a texture analyzer highlights the sensitivity and accuracy of the test, enabling a thorough examination of the structural integrity of the pasta. Significantly, the pasta had a moisture level of 28% when it was pressed. Pasta's elasticity, hardness, and general structure are all greatly influenced by its moisture content. The designated moisture content is essential for understanding the texture analyzer results and adds important context to the experimental setup.

The utilization of the structurometer ST-1M, a widely recognized instrument for assessing the mechanical characteristics of food items, in this investigation suggests a thorough methodology to comprehend the influence of millet incorporation on pasta texture. The pasta's capacity to hold its shape while cooking and further processing largely depends on factors like hardness, chewiness, and resilience, all of which were probably evaluated by the device. The texture qualities of the premium grade grits-based pasta and the millet-fortified pasta are visually represented by the results in Figure 3. This comparison makes it possible to directly evaluate any differences in shape preservation between the two formulas.

The presence of 7.7% millet in the pasta recipe might have affected its textural characteristics and capacity to hold its shape while cooking. The structurometer ST-1M's data should provide information about how millet affects the hardness and resilience of pasta by interacting with the pasta matrix. Comprehending the alterations in the texture of the pasta is essential for forecasting its performance during cooking and other processing phases, in addition to setting consumer expectations. A thorough grasp of the impacts of millet addition on pasta shape maintenance is made possible by integrating data on moisture content, using an accurate texture analyzer, and the graphical display of results, all of which improve the study's robustness.

In summary, the careful method of analyzing the textural qualities of pasta containing millet is demonstrated using the structure meter ST-1M to measure form preservation and reveal moisture content. These findings establish the foundation for future developments in the creation of pasta products that satisfy both nutritional and textural expectations by deepening our understanding of how different grains affect the structural properties of pasta.

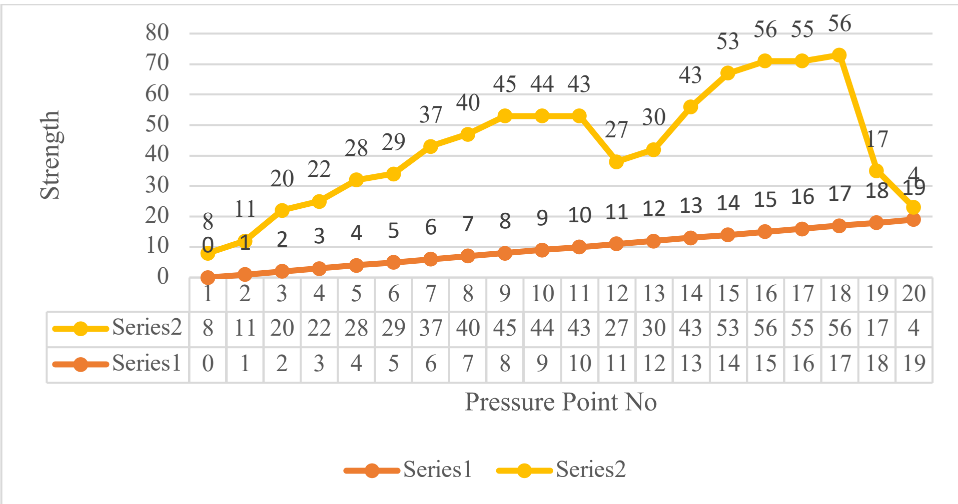


Figure 4 Strength indicators of pasta made from high-grade grits control (sample No. 2).

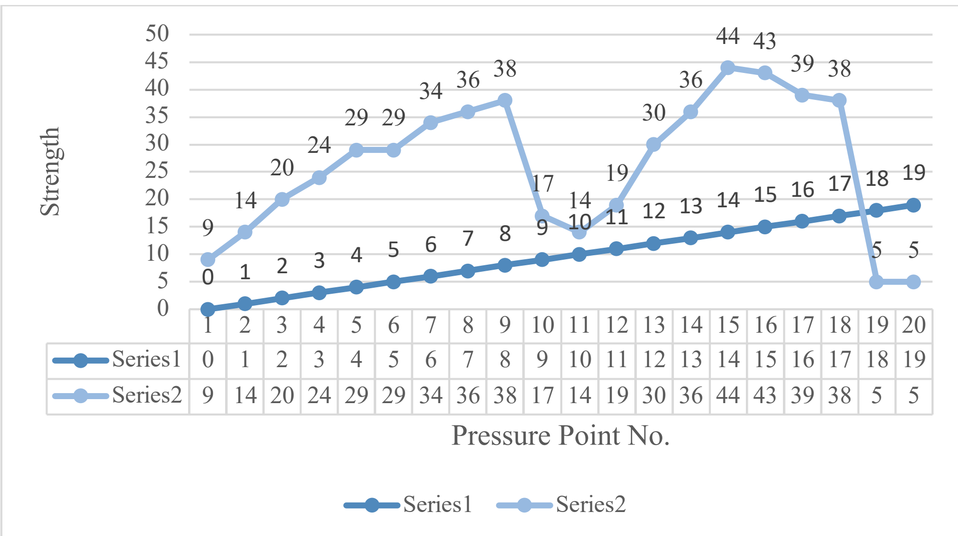
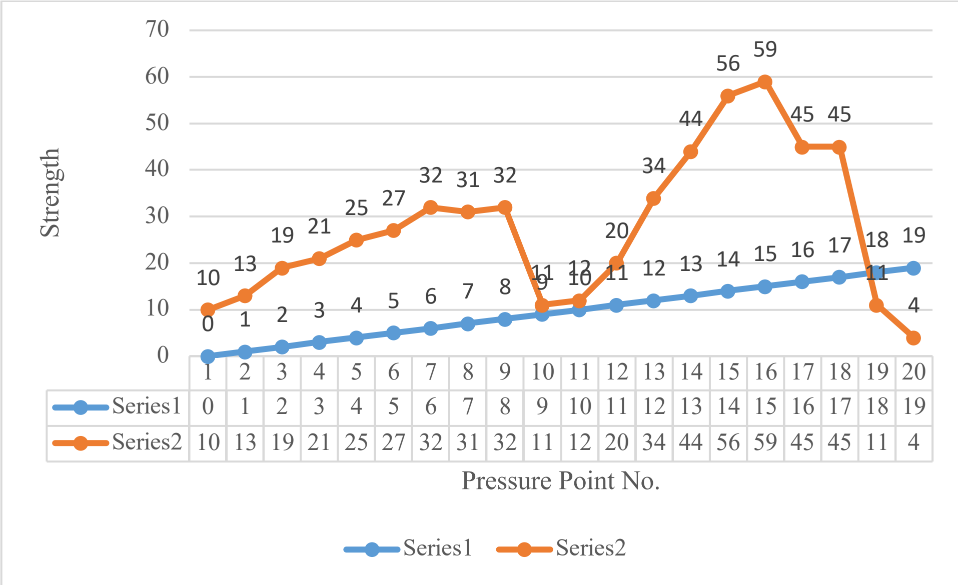
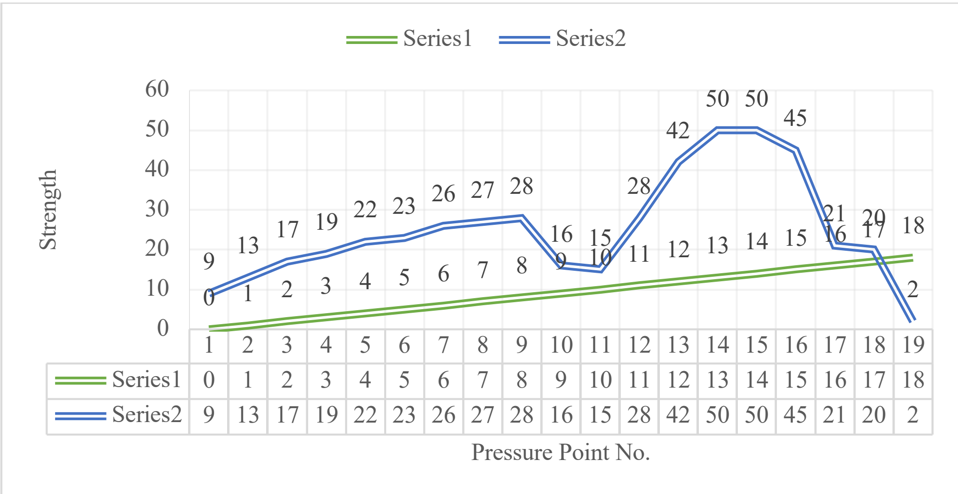


Figure 5 Strength indicators of pasta made from high-grade grits control (sample No. 3).



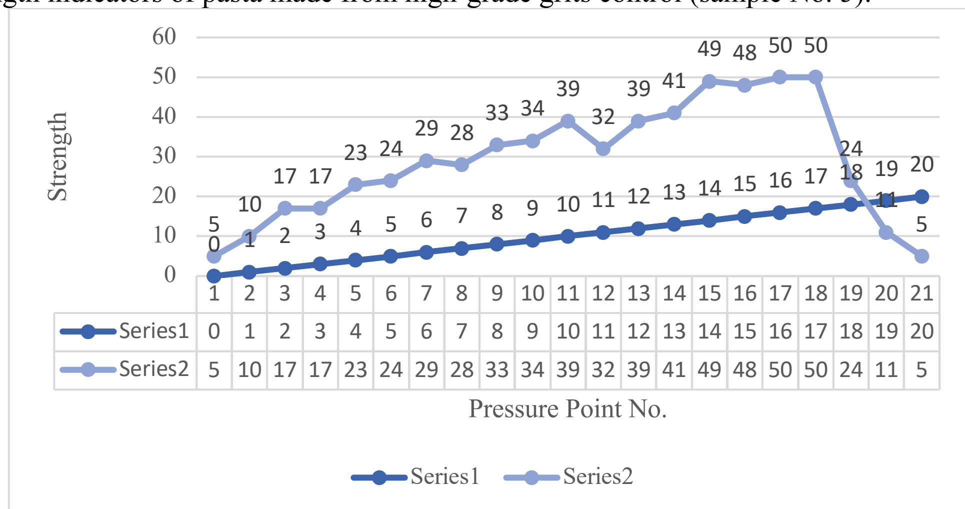
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series2	10	13	19	21	25	27	32	31	32	11	12	20	34	44	56	59	45	45	11	4

Figure 6 Strength indicators of pasta made from high-grade grits control (sample No. 4).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series2	9	13	17	19	22	23	26	27	28	16	15	28	42	50	50	45	21	20	2

Figure 7 Strength indicators of pasta made from high-grade grits control (sample No. 5).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series2	5	10	17	17	23	24	29	28	33	34	39	32	39	41	49	48	50	50	24	11	5

Figure 8 Strength indicators of pasta made from high-grade grits control (sample No. 6).

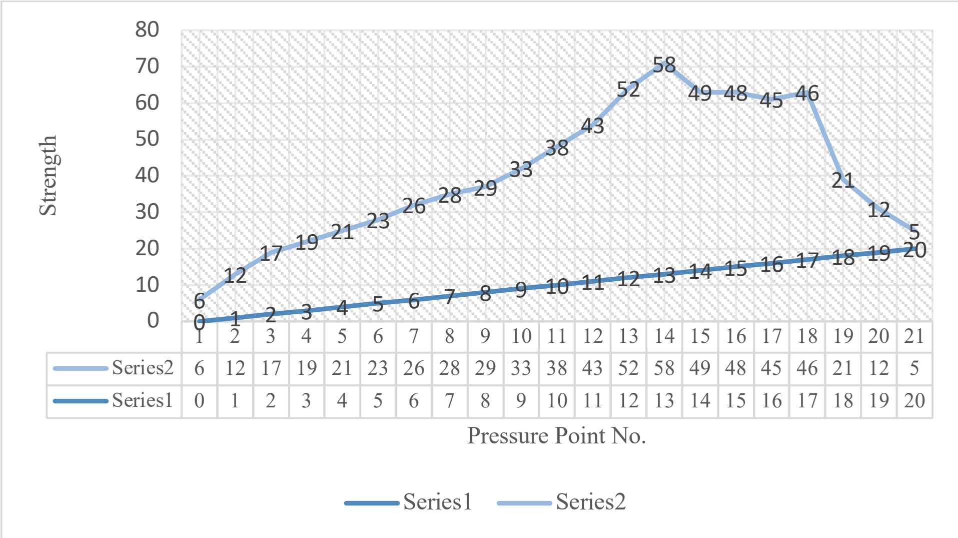


Figure 9 Strength indicators of pasta made from high-grade grits control (sample No. 7).

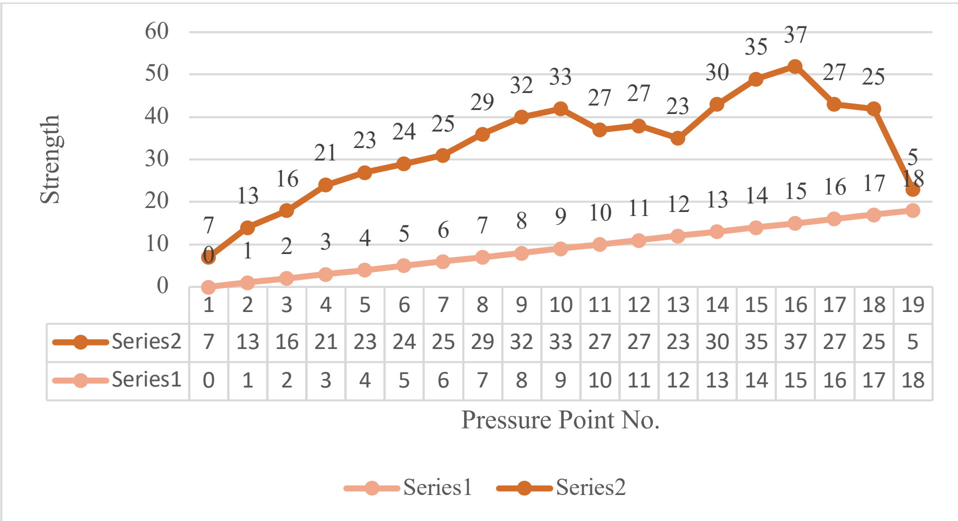


Figure 10 Strength indicators of pasta made from high-grade grits control (sample No. 8).

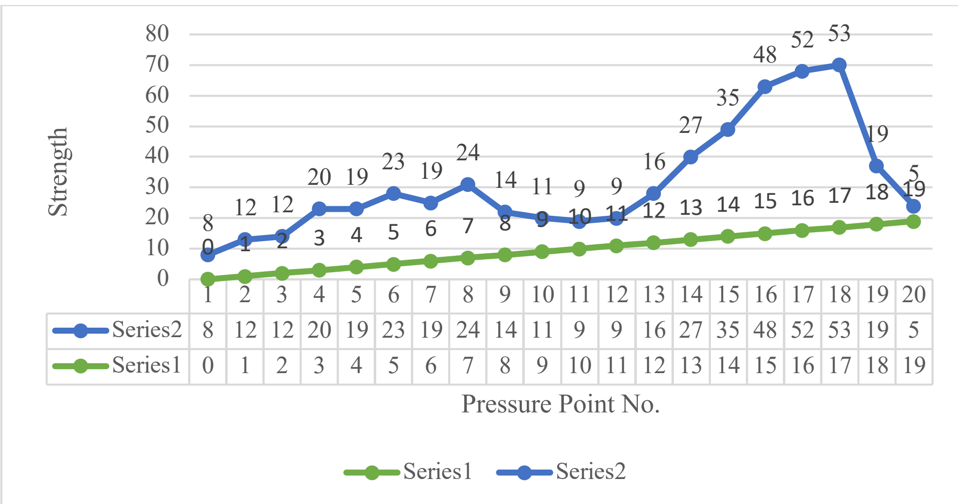


Figure 11 Strength indicators of pasta made from high-grade grits control (sample No. 9).

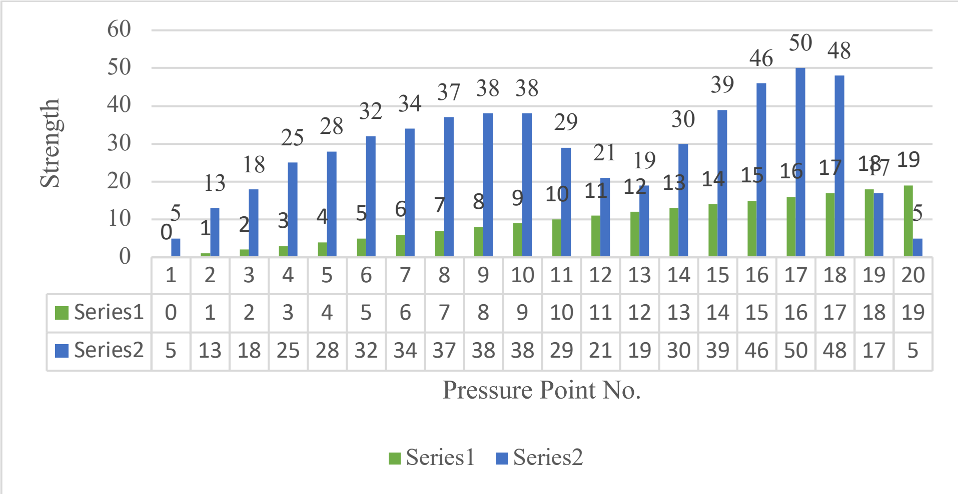


Figure 12 Strength indicators of pasta made with the addition of millet 7.7% after cooking (sample No. 9).

The strength of the pasta is measured by adding millet at 7.7% and 15.5% **[18]**, **[19]**, **[20]**, **[21]**, **[22]**. As shown in Figures 3–12, we first estimate the pasta strength of the high-grade grits control (Samples No. 1, 2, 3,4,5,6,7,8,9), which were used in the experiments.

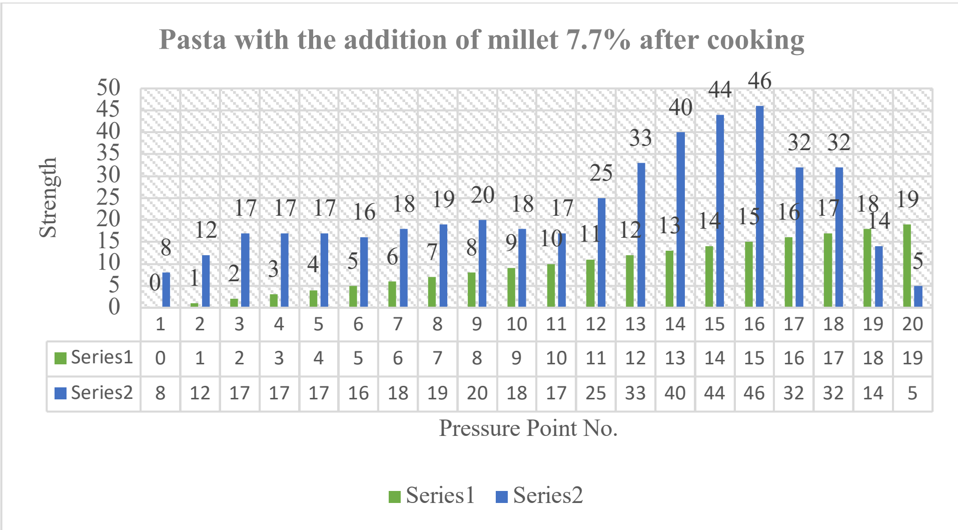


Figure 13 Data of the "Structurometer ST-1M" (sample No. 1).

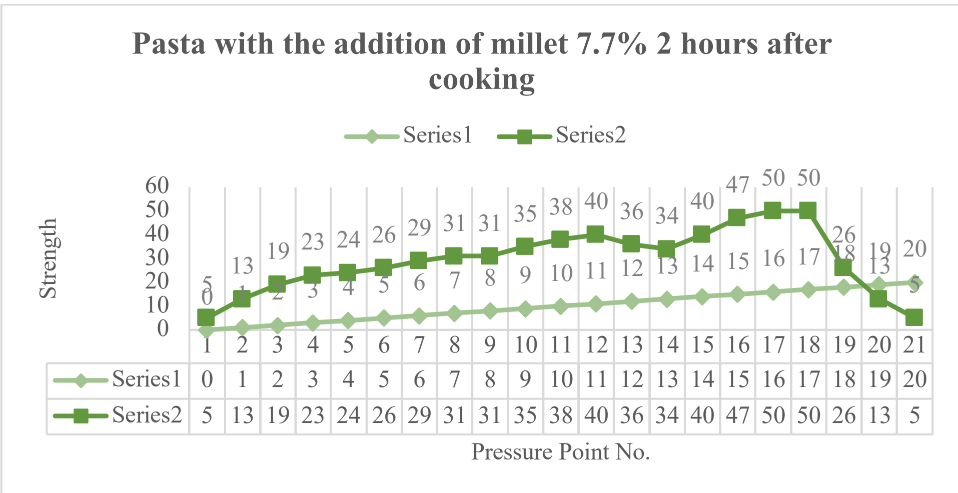


Figure 14 Data of the "Structurometer ST-1M" (sample No. 2).

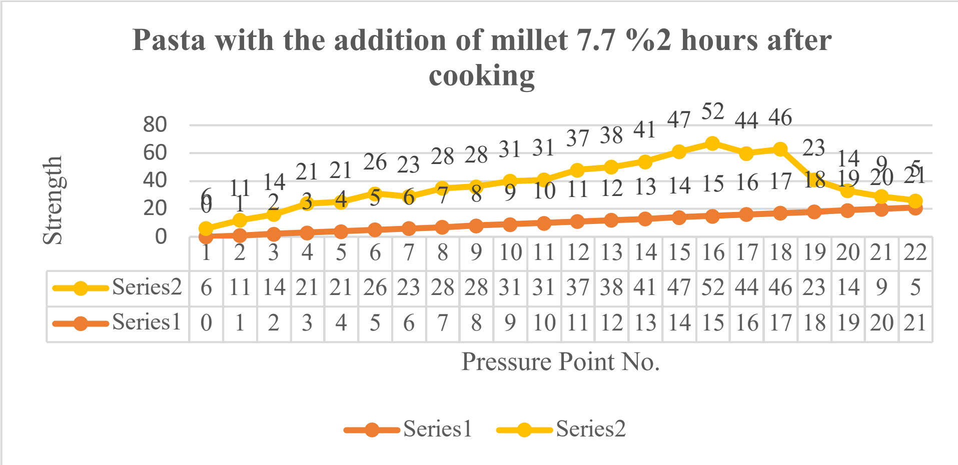


Figure 15 Data of the "Structurometer ST-1M" (sample No. 3).

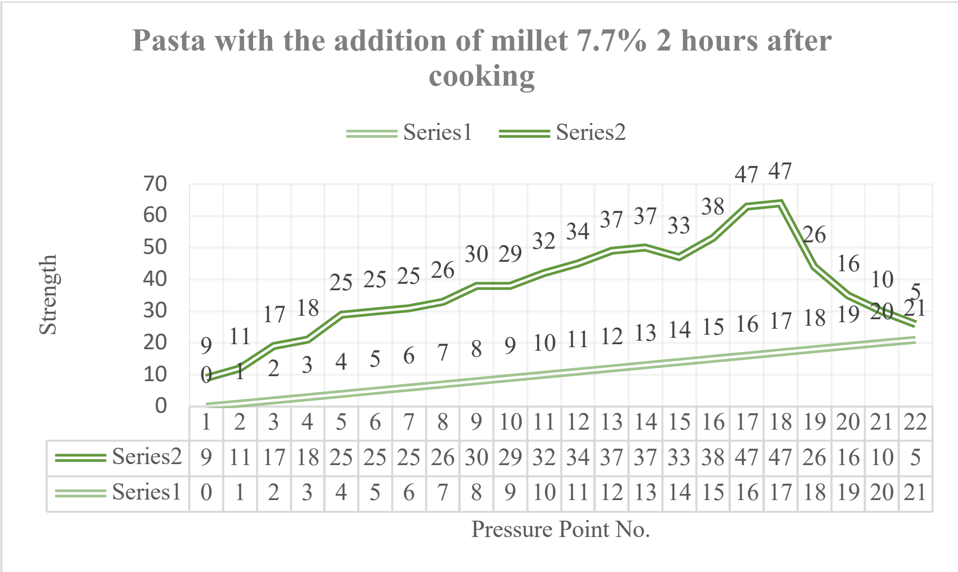


Figure 16 Data of the "Structurometer ST-1M" (sample No. 4).

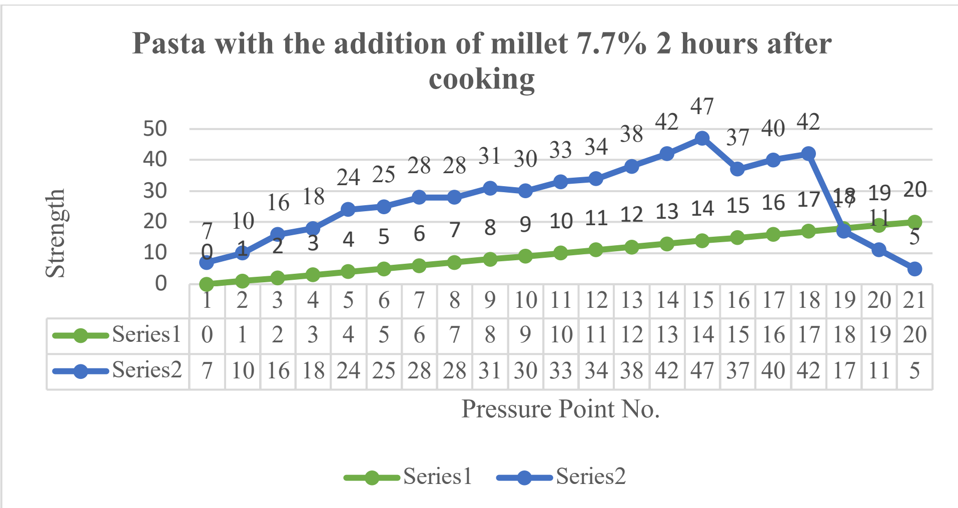
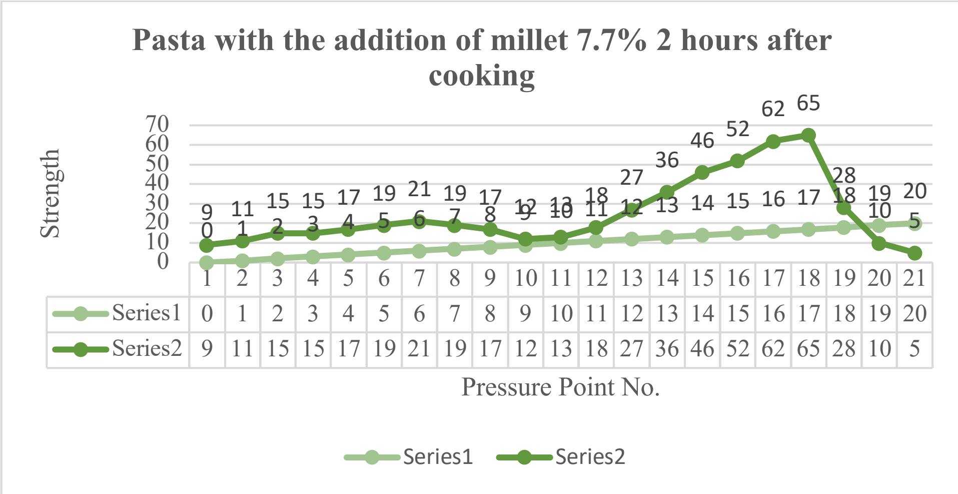
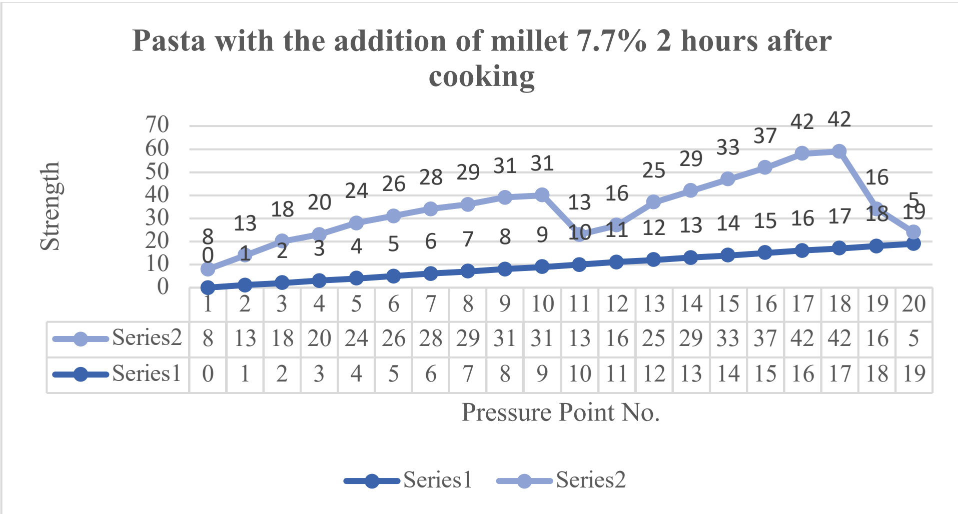


Figure 17 Data of the "Structurometer ST-1M" (sample No. 5).



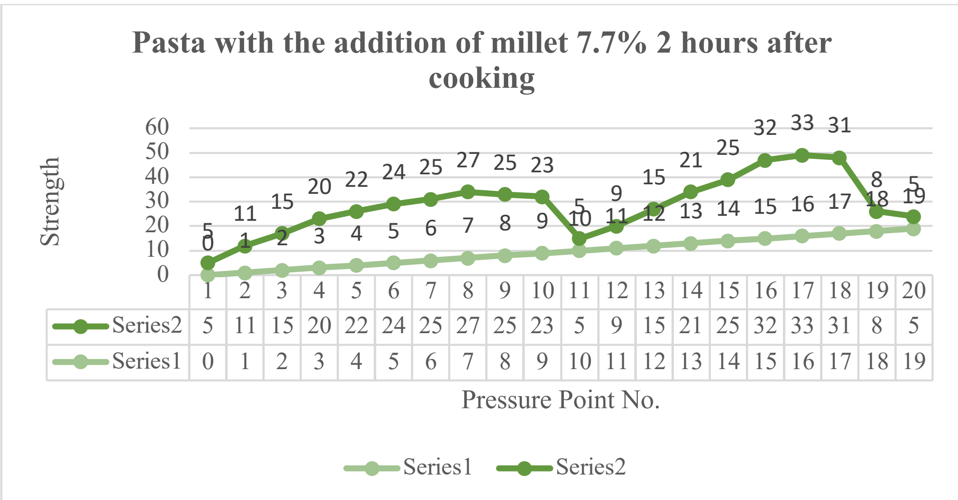
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series2	9	11	15	15	17	19	21	19	17	12	13	18	27	36	46	52	62	65	28	10	5

Figure 18 Data of the "Structurometer ST-1M" (sample No. 6).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series2	8	13	18	20	24	26	28	29	31	31	13	16	25	29	33	37	42	42	16	5
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Figure 19 Data of the "Structurometer ST-1M" (sample No. 7).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series2	5	11	15	20	22	24	25	27	25	23	5	9	15	21	25	32	33	31	8	5
Series1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Figure 20 Data of the device "Structurometer ST-1M" (sample No. 8).

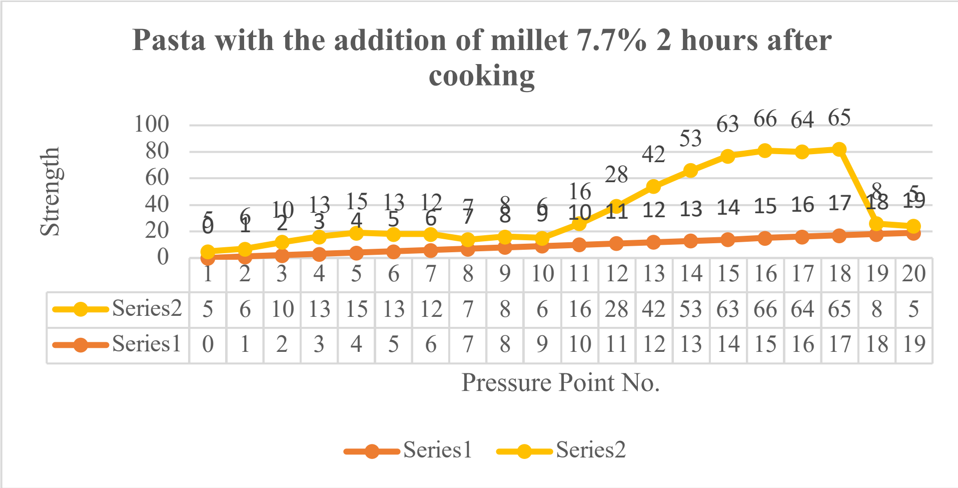


Figure 21 Data of the device "Structurometer ST-1M" (sample No. 9).

Standardized testing methods, specifically those described in GOST 31964-2012 clauses 7.7.1 and 7.7.2, are used in this study to demonstrate its dedication to thorough and trustworthy analytical preparation. A typical pasta sample (50 g) was used for testing, and the GOST standard's stipulated clauses were followed. This systematic approach is necessary to guarantee consistency and comparability in the outcomes, giving the following analytical procedures a strong basis **[23]**. Investigating pasta using the ST-1M structural meter increases the study's accuracy even more.

As was previously mentioned, the structurometer is a specialist tool that may offer in-depth information about the textural characteristics of food products. The random order in which the pasta was taken out of the vessel, in this instance, points to a careful analysis of several samples that captured a range of conditions and variances in the textural qualities of the pasta. Visualizations or graphical representations of the data from the structurometer analysis are probably shown in Figures 13-21. Understanding the patterns, trends, and variances in the texture and structure of the pasta samples is made much easier with the help of these figures. The results' visual component increases accessibility and clarity, making it easier for readers and researchers to understand the data **[24]**.

The structurometer analysis yields valuable information about the pasta samples' resilience, stiffness, and shape retention. It also enables a detailed comprehension of how adding millet affects these textural characteristics. The analysis is typical and considers any variances within the samples because of the random order in which the samples are removed from the vessel. These thorough analytical methods improve the study's validity and dependability. It exhibits a dedication to scientific rigor and a systematic approach in evaluating the effect of millet inclusion on pasta's textural characteristics **[25]**. The advancement of knowledge on incorporating alternative grains in pasta formulations depends on these in-depth analyses.

To sum up, using the structurometer ST-1M for pasta evaluation and the adherence to established testing procedures demonstrate a thorough and systematic approach to assessing the textural properties of pasta that has been millet added. Setting the bar high for similar research in the realm of food science and technology, the thorough analyses provide insightful information about the complex interactions between ingredients, processing parameters, and the structural qualities of the pasta as a result.

The research conformed to the approved methodology delineated in GOST 31964-2012, offering a uniform structure for assessing the safety and caliber of pasta compositions **[26]**. The study's findings provide intriguing new information about the mechanical characteristics of pasta that has 7.7% millet added to it, especially regarding safety as expressed in Newtons (N) **[27]**. Pasta added to the recipe "after 2 hours from the moment of cooking" and pasta added "with the addition of 7.7% millet after cooking" were the two different scenarios that were taken into consideration **[28]**.

The minor safety variations noted "after 2 hours from the moment of cooking" for pasta that had millet added indicate that the mechanical properties hold steady during this post-cooking phase. These variations range from 1-2 N. However, adding millet "after cooking" results in a more noticeable variation in safety data, ranging from 4 to 24 N. This difference could be explained by the pasta's varying moisture level at different times, affecting the work needed for mechanical testing **[29]**.

Moisture content plays an important function, particularly in the "after cooking" stages when the presence of water may impact the pasta's structural integrity. The ease of deformation is influenced by moisture content; in this case, less effort is required. The fact that driving is one of the outside elements influencing this reduction in effort highlights the importance of considering the environment while assessing the mechanical qualities of pasta **[28]**, **[29]**. The behavior of starch and gluten throughout the cooking process significantly influences the observed differences. As water is absorbed, wheat starch in aqueous suspension swells and becomes softer **[30]**. Whereas starch granules would otherwise liquefy after boiling, gluten, a protein found in wheat, keeps the grains' mass. The starch matrix gets fixed and strengthened when gluten denaturation occurs during cooking **[31]**. The gluten denaturation process is responsible for the denser structure seen in pasta "after 2 hours from the moment of cooking". Given the impact of gluten on the mechanical characteristics of pasta, this structural densification leads to increased mechanical effort **[29]**.

In conclusion, the study explores the mechanical properties of pasta including millet, considering the influence of starch and gluten behavior during cooking and post-cooking times **[32]**. The intricate results illuminated the interactions between components and cooking methods, offering insightful knowledge for enhancing pasta recipes to satisfy safety and structural integrity standards.

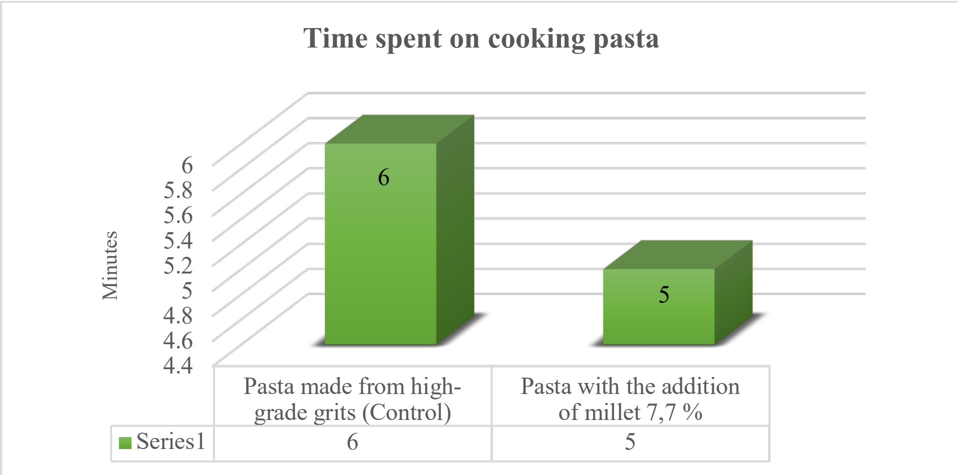


Figure 22 Time spent cooking pasta using pasta with millet 7.7% and control sample made from grade grits.

As previously mentioned, adding millet to pasta formulations improves mechanical qualities and significantly reduces cooking time **[33]**. The study emphasizes that adding 7.7% millet causes the pasta's ideal cooking time to decrease **[34]**. Given that pasta preparation efficiency heavily influences customer tastes and convenience, this shorter cooking time is a major and useful benefit **[35]**. As evaluating pasta requires maximizing its cooking properties, the results of this study support earlier research that indicates the ideal cooking time after pasta fortification should be lowered **[36]**. Here, the cooking time significantly improves over the lengthy cooking durations that product makers frequently list on labels (8 to 11 minutes) **[37]**. In this instance, the cooking time is considerably shortened to just 5 minutes. Customers' preparation time is streamlined, and there is also an energy savings benefit from this large reduction in cooking time **[38]**. Pasta readiness was evaluated following GOST 31964-2012, guaranteeing that the testing procedure complies with accepted norms. This standardized approach makes meaningful comparisons with industry norms possible, enabling consistent and reliable evaluation of pasta quality **[39]**.

The millet and pasta matrix interaction during cooking is probably the cause of the shorter cooking time. A quicker cooking procedure could result from the intrinsic qualities of millet, such as its composition and capacity for effective water absorption, which could hasten hydration and gelatinization **[40]**. This supports the reported decrease in cooking time and emphasizes millet's potential as a useful component to raise pasta products' overall cooking efficiency **[41]**. The study concludes that adding millet to pasta not only makes it safer and has better mechanical qualities but also considerably cuts down on cooking time, which helps customers and may save energy **[42]**. These findings highlight the importance of striking a balance between nutritional content, convenience, and cooking efficiency in the production of pasta products, which adds to the continuing investigation of alternative grains in pasta formulations **[42]**, **[43]**.

CONCLUSION

According to the research results, pasta with 7.7% millet added to it looks and preserves its form similarly to pasta prepared with premium quality grits, as long as the cooking time is shortened. We were able to effectively assess and compare the cooked pasta's consumer features (shape preservation indicators) over a certain length of time. Pasta takes less time to cook when millet is included. After pasta fortification, the ideal cooking time is typically shortened. Five minutes are needed for pasta cooking. However, these days, product makers list the amount of time that pasta needs to be cooked on their labels 8, 9, 10, or 11 minutes. In addition, studies on pasta were carried out based on the physicochemical characteristics (strength), and the outcomes were contrasted with a control sample (pasta prepared from premium grits). According to the investigation's findings, the strength indications are almost under control. These findings highlight the potential for adding other grains, such as millet, to improve the nutritional profile of pasta products and offer insightful information about optimizing pasta formulations for increased cooking efficiency. Intending to balance customer preferences, nutritional value, and cooking convenience in pasta formulas, the study's findings lay the groundwork for future research and product development in the food sector.

REFERENCES

1. Bchir, B., Karoui, R., Danthine, S., Blecker, C., Besbes, S., & Attia, H. (2022). Date, Apple, and Pear By-Products as Functional Ingredients in Pasta: Cooking Quality Attributes and Physicochemical, Rheological, and Sensorial Properties. In Foods (Vol. 11, Issue 10, p. 1393). MDPI AG. https://doi.org/10.3390/foods11101393
2. Minarovičová, L., Lauková, M., Kohajdová, Z., Karovičová, J., & Kuchtová, V. (2017). Effect of pumpkin powder incorporation on cooking and sensory parameters of pasta. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 11, Issue 1, pp. 373–379). HACCP Consulting. https://doi.org/10.5219/743
3. Yadav, D. N., Sharma, M., Chikara, N., Anand, T., & Bansal, S. (2014). Quality Characteristics of Vegetable-Blended Wheat–Pearl Millet Composite Pasta. In Agricultural Research (Vol. 3, Issue 3, pp. 263–270). Springer Science and Business Media LLC. https://doi.org/10.1007/s40003-014-0117-7
4. Linares-García, L., Repo-Carrasco-Valencia, R., Glorio Paulet, P., & Schoenlechner, R. (2019). Development of gluten-free and egg-free pasta based on quinoa (Chenopdium quinoa Willd) with addition of lupine flour, vegetable proteins and the oxidizing enzyme POx. In European Food Research and Technology (Vol. 245, Issue 10, pp. 2147–2156). Springer Science and Business Media LLC. https://doi.org/10.1007/s00217-019-03320-1
5. Viraktamath, C. S., Raghavendra, G., & Desikachar, H. S. R. (1971). Use of milling machinery for commercial pearling of grain sorghum (Jowar) and culinary uses for pearled sorghum products. In Journal of Food Science and Technology (Vol. 8, Issue 1, pp. 11–13). Springer Science+Business Media.
6. Purseglove, J. W. (1972). Tropical crops: Monocotyledons. Longman Group Limited edition, London, (pp. 334–336).
7. Vaidehi, M. P., Bharati, P., & Reddy, L. (1985). High-Protein Biscuits made with Ragi Flour and Oil-Seed Flour Blends. In Food and Nutrition Bulletin (Vol. 7, Issue 4, pp. 1–4). SAGE Publications. https://doi.org/10.1177/156482658500700412
8. Veena, B., Chimmad, B. V., Naik, R. K., & Shantakumar, G. (2004). Development of barnyard millet based traditional foods. In Karnataka Journal of Agricultural Sciences (Vol. 17, Issue 3, pp. 522–527). University of Agricultural Sciences.
9. Devi, G. S., Palanimuthu, V., & Arunkumar, P. (2014). Studies on development and storage of kodo millet-based Pasta. In International Journal of Processing and Post Harvest Technology (Vol. 5, Issue 1, pp. 33–40). Hind Agri-Horticultural Society.
10. Szedljak, I., Szántai-Kőhegyi, K., Tóth, M., & Bernhardt, B. (2014). Monitoring of chemical parameters of qualitative pasta samples containing millet flours during storage experiments. In Acta Alimentaria (Vol. 43, Issue Supplement 1, pp. 156–163). Akademiai Kiado Zrt. https://doi.org/10.1556/aalim.43.2014.suppl.22
11. Authority nutrition. (2023, October 20). In Authority Nutrition. Retrieved from https://www.authoritynutrition.net/pitanie/.
12. Macaroni products. GOST 31964-2012. Pasta products. Acceptance rules and methods of quality determination.
13. Lawal, O. M., Sanni, O., Oluwamukomi, M., Fogliano, V., & Linnemann, A. R. (2021). The addition of fluted pumpkin (Telfairia occidentalis) leaf powder improves the techno-functional properties of cassava pasta. In Food Structure (Vol. 30, p. 100241). Elsevier BV. https://doi.org/10.1016/j.foostr.2021.100241

14. Tagliasco, M., Fogliano, V., & Pellegrini, N. (2021). Pasta regrind: The effect of drying temperature on its functionality as a novel ingredient. In Food Structure (Vol. 30, p. 100230). Elsevier BV. https://doi.org/10.1016/j.foostr.2021.100230

15. Yan, W., Yin, L., Zhang, M., Zhang, M., & Jia, X. (2021). Gelatinization, Retrogradation and Gel Properties of Wheat Starch–Wheat Bran Arabinoxylan Complexes. In Gels (Vol. 7, Issue 4, p. 200). MDPI AG. https://doi.org/10.3390/gels7040200

16. Karimova, G., Niyazbekova, R., Al Azzam, K., Mashanova, N., Negim, E.-S., & Ibzhanova, A. (2023). Development of new technologies (recipes) to produce pasta with the addition of millet and the determination of organoleptic and physicochemical quality indicators. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 17, pp. 371–390). HACCP Consulting. https://doi.org/10.5219/1829

17. GOST 572-2016 "Millet grain ground. Technical conditions". Retrieved from

18. Schmid, T., Loschi, M., Hiltbrunner, J., & Müller, N. (2023). Assessment of the suitability of millet for the production of pasta. In Applied Food Research (Vol. 3, Issue 1, p. 100247). Elsevier BV. https://doi.org/10.1016/j.afres.2022.100247

19. Jalgaonkar, K., Jha, S. K., Mahawar, M. K., & Yadav, D. N. (2019). Pearl millet based pasta: optimization of extrusion process through response surface methodology. In Journal of Food Science and Technology (Vol. 56, Issue 3, pp. 1134–1144). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-019-03574-3

20. Wójtowicz, A., Combrzyński, M., Biernacka, B., Oniszczuk, T., Mitrus, M., Różyło, R., Gancarz, M., & Oniszczuk, A. (2023). Application of Edible Insect Flour as a Novel Ingredient in Fortified Snack Pellets: Processing Aspects and Physical Characteristics. In Processes (Vol. 11, Issue 9, p. 2561). MDPI AG. https://doi.org/10.3390/pr11092561

21. Jakab, I., Tormási, J., Dhaygude, V., Mednyánszky, Zs., Sipos, L., & Szedljak, I. (2020). Cricket flour-laden millet flour blends' physical and chemical composition and adaptation in dried pasta products. In Acta Alimentaria (Vol. 49, Issue 1, pp. 4–12). Akademiai Kiado Zrt. https://doi.org/10.1556/066.2020.49.1.2

22. Ho, I., Peterson, A., Madden, J., Huang, E., Amin, S., & Lammert, A. (2022). Will It Cricket? Product Development and Evaluation of Cricket (Acheta domesticus) Powder Replacement in Sausage, Pasta, and Brownies. In Foods (Vol. 11, Issue 19, p. 3128). MDPI AG. https://doi.org/10.3390/foods11193128

23. Carcea, M. (2020). Quality and Nutritional/Textural Properties of Durum Wheat Pasta Enriched with Cricket Powder. In Foods (Vol. 9, Issue 9, p. 1298). MDPI AG. https://doi.org/10.3390/foods9091298

24. Coello, K. E., Peñas, E., Martinez-Villaluenga, C., Elena Cartea, M., Velasco, P., & Frias, J. (2021). Pasta products enriched with moringa sprout powder as nutritive dense foods with bioactive potential. In Food Chemistry (Vol. 360, p. 130032). Elsevier BV. https://doi.org/10.1016/j.foodchem.2021.130032

25. Bchir, B., Karoui, R., Danthine, S., Blecker, C., Besbes, S., & Attia, H. (2022). Date, Apple, and Pear By-Products as Functional Ingredients in Pasta: Cooking Quality Attributes and Physicochemical, Rheological, and Sensorial Properties. In Foods (Vol. 11, Issue 10, p. 1393). MDPI AG.

26. Lisiecka, K., Wójtowicz, A., Dziki, D., & Gawlik-Dziki, U. (2019). The influence of Cistus incanus L. leaves on wheat pasta quality. In Journal of Food Science and Technology (Vol. 56, Issue 9, pp. 4311–4322). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-019-03900-9

27. Benhur, D. R., Bhargavi, G., Kalpana, K., Vishala, A. D., Ganapathy, K. N., & Patil, J. V. (2015). Development and standardization of sorghum pasta using extrusion technology. In Journal of Food Science and Technology (Vol. 52, Issue 10, pp. 6828–6833). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-015-1801-8

28. Bianchi, F., Tolve, R., Rainero, G., Bordiga, M., Brennan, C. S., & Simonato, B. (2021). Technological, nutritional and sensory properties of pasta fortified with agro-industrial by-products: a review. In International Journal of Food Science & Technology (Vol. 56, Issue 9, pp. 4356–4366). Wiley. https://doi.org/10.1111/ijfs.15168

29. Simonato, B., Trevisan, S., Tolve, R., Favati, F., & Pasini, G. (2019). Pasta fortification with olive pomace: Effects on the technological characteristics and nutritional properties. In LWT (Vol. 114, p. 108368). Elsevier BV. https://doi.org/10.1016/j.lwt.2019.108368

30. Tolve, R., Pasini, G., Vignale, F., Favati, F., & Simonato, B. (2020). Effect of Grape Pomace Addition on the Technological, Sensory, and Nutritional Properties of Durum Wheat Pasta. In Foods (Vol. 9, Issue 3, p. 354). MDPI AG. https://doi.org/10.3390/foods9030354

31. Çabuk, B., & Yılmaz, B. (2020). Fortification of traditional egg pasta (erişte) with edible insects: nutritional quality, cooking properties and sensory characteristics evaluation. In Journal of Food Science and Technology (Vol. 57, Issue 7, pp. 2750–2757). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-020-04315-7

32. Tolve, R., Simonato, B., Rainero, G., Bianchi, F., Rizzi, C., Cervini, M., & Giuberti, G. (2021). Wheat Bread Fortification by Grape Pomace Powder: Nutritional, Technological, Antioxidant, and Sensory Properties. In Foods (Vol. 10, Issue 1, p. 75). MDPI AG. https://doi.org/10.3390/foods10010075
33. Ozgoren, E., & Yapar, A. (2018). Effect of the addition of smoked trout fillet powder to the quality properties of pastan[JB]. In Italian Journal of Food Science, 31(1). https://doi.org/10.14674/IJFS-1263
34. Hammad, E., & Abo-Zaid, E. (2020). Properties of Noodles Fortification with Turnip Leave powder. In Journal of Food and Dairy Sciences (Vol. 11, Issue 7, pp. 209–213). Egypts Presidential Specialized Council for Education and Scientific Research. https://doi.org/10.21608/jfds.2020.111755
35. Kamble, V., Bhuvaneshwari, G., Jagadeesh, S. L., M. Ganiger, V., & Terdal, D. (2018). Development and Evaluation of Cooking Properties of Instant Noodles Incorporated with Drumstick Leaf Powder and Defatted Soybean Flour. In International Journal of Current Microbiology and Applied Sciences (Vol. 7, Issue 2, pp. 3642–3651). Excellent Publishers. https://doi.org/10.20546/ijcmas.2018.702.433
36. Yang, T., Wang, P., Zhou, Q., Zhong, Y., Wang, X., Cai, J., Huang, M., & Jiang, D. (2022). Effects of Different Gluten Proteins on Starch's Structural and Physicochemical Properties during Heating and Their Molecular Interactions. In International Journal of Molecular Sciences (Vol. 23, Issue 15, p. 8523). MDPI AG. https://doi.org/10.3390/ijms23158523
37. Fan, J.-L., Han, N., & Chen, H.-Q. (2021). Physicochemical and structural properties of wheat gluten/rice starch dough-like model. In Journal of Cereal Science (Vol. 98, p. 103181). Elsevier BV. https://doi.org/10.1016/j.jcs.2021.103181
38. Cappelli, A., Oliva, N., & Cini, E. (2020). A Systematic Review of Gluten-Free Dough and Bread: Dough Rheology, Bread Characteristics, and Improvement Strategies. In Applied Sciences (Vol. 10, Issue 18, p. 6559). MDPI AG. https://doi.org/10.3390/app10186559
39. Ren, Y., Linter, B. R., Linforth, R., & Foster, T. J. (2020). A comprehensive investigation of gluten free bread dough rheology, proving and baking performance and bread qualities by response surface design and principal component analysis. In Food & Function (Vol. 11, Issue 6, pp. 5333–5345). Royal Society of Chemistry (RSC). https://doi.org/10.1039/d0fo00115e
40. Brandner, S., Becker, T., & Jekle, M. (2019). Classification of starch-gluten networks into a viscoelastic liquid or solid, based on rheological aspects — A review. In International Journal of Biological Macromolecules (Vol. 136, pp. 1018–1025). Elsevier BV. https://doi.org/10.1016/j.ijbiomac.2019.06.160
41. Yano, H. (2019). Recent practical researches in the development of gluten-free breads. In npj Science of Food (Vol. 3, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41538-019-0040-1
42. Bresciani, A., Pagani, M. A., & Marti, A. (2022). Pasta-Making Process: A Narrative Review on the Relation between Process Variables and Pasta Quality. In Foods (Vol. 11, Issue 3, p. 256). MDPI AG. https://doi.org/10.3390/foods11030256
43. Ospanov, A., Muslimov, N., Timurbekova, A., Nurdan, D., & Zhalelov, D. (2022). Mixing of flour mixture components in the production of pasta from nontraditional raw materials. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 375–387). HACCP Consulting. https://doi.org/10.5219/1749

Funds:

This research received no external funding.

Acknowledgments:

eng - IRN BR12967830 "Development of technical regulation tools to improve the efficiency, safety, resource-saving of food production and eco-friendly packaging."

Conflict of Interest:

The authors declare no conflict of interest.

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

Contact Address:

***Gulmaida Karimova**, Standardization, Certification and Metrology" (by industry), Technical Faculty, Department of Standardization, Metrology and Certification NAO, Kazakh Agrotechnical University named after S. Seifullin, Kazakhstan,
E-mail: Gulmaida@mail.ru
ORCID: https://orcid.org/0000-0002-7190-8847

Rimma Niyazbekova, Standardization, Certification and Metrology" (by industry), Technical Faculty, Department of Standardization, Metrology and Certification NAO, Kazakh Agrotechnical University named after S. Seifullin, Kazakhstan,
E-mail: rimma.n60@mail.ru
ORCID: https://orcid.org/0000-0001-8688-1408

Khaldun Al Azzam, The University of Jordan, Department of Chemistry, School of Science, 11942 Amman, Jordan,
E-mail: azzamkha@yahoo.com
ORCID: https://orcid.org/0000-0003-4097-6991

El-Sayed Negim, Satbayev University, School of Petroleum Engineering, 22 Satpayev Street, 050013 Almaty, Kazakhstan; School of Materials Science and Green Technologies, Kazakh-British Technical University, 59 Tole bi St., 050000, Almaty, Kazakhstan,
E-mail: elashmawi5@yahoo.com
ORCID: https://orcid.org/0000-0002-4370-8995

Corresponding author: *